THE TRANSPORTATION ECONOMICS OF THE SOYBEAN PROCESSING INDUSTRY

BY

EARL CLIFFORD HEDLUND

B.S., University of Nebraska, 1938
M.S., University of Illinois, 1939

AN ABSTRACT OF A THESIS

SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS
FOR THE DEGREE OF DOCTOR OF PHILOSOPHY IN AGRICULTURAL ECONOMICS
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THE TRANSPORTATION ECONOMICS OF THE SOYBEAN PROCESSING INDUSTRY

The economic importance of transportation cost has always been evident in conditioning the organization and location of manufacturing industries and of individual plants in the United States.

This investigation was initiated primarily to evaluate the importance of the various aspects of transportation to the soybean processing industry, with particular reference to their influence on the location of processing plants. Transportation cost, as affected by the commonly used institution of "processing-in-transit," has received major attention.

Cost data were computed largely from freight rates as compiled from numerous applicable freight tariffs as of June 30, 1946. Decisions of the United States Supreme Court and the Interstate Commerce Commission were relied on for information relative to the development and current status of the railroad rate structure and the institution of transit. Various publications of the United States Department of Agriculture and the United States Bureau of the Census provided certain source material, as did unpublished data from these and other sources in the transportation and soybean processing industries.

A Theory Of Location

The problem of location, from a transportation point of view, is basically one of balancing the transport advantages of nearness to markets and nearness to raw materials. Under any given combination of raw material areas and markets, there is a point at which total costs of transport incident to manufacture and delivery are a minimum. Since there are generally several markets and raw material areas, possible combinations are large in number, making it necessary to

determine which combination will survive under competition. This reasoning makes it necessary to integrate the theory of market areas with that of plant location, since location relative to the entire market may determine which processing plants will survive.

One of the more important factors to consider in plant location is the degree of weight lost in processing, or the ratio of the weight of material used to the weight of the product. The greater the degree of weight lost in the processing, the greater will be the tendency to locate at the raw material source. A second factor of importance is the relation between the ton mile cost of shipping the raw material and the product. The higher the rate on the product compared to that on the raw material, the greater the tendency to locate in the market area. The degree to which the general level of freight rates is constructed to vary with distance is a third factor affecting transport costs and plant orientation. Rates proportional to distance will operate in a different manner than those less than proportionate to distance.

The relative pull of each of the materials used in processing, according to the above factors, will condition final plant location, insofar as transport cost is concerned. Every form of processing generally finds a transport cost advantage by locating either at the source of one raw material or at the market. From a transport cost point of view, there is generally no justification to locate at any point in between these two areas.

Some commodities are tied to the raw material and market areas by their very nature. Freight costs cannot change these considerations. The degree of perishability of a commodity and its adaptibility to preservation are important in location. The extent of the use of materials generally available everywhere is often important. In the case of integrated production procedures, the location of subordinate processes near the major plant is often advantageous.

The costs of transportation as computed according to the above principles, as applied to the particular commodity and type of processing at hand, will indicate the tendency to locate either at the raw material or market area. This represents the transport cost influence, and while this cost is important, the influences of other locational factors must be considered. One of the most important of these considerations is that of the availability and cost of labor. Others are cost and availability of fuel, water, power, capital, and so forth. A further consideration often of importance is that resulting from the production of joint products for which the markets are different and widely separated. This factor will force processing plants toward the raw material area in order to minimize overall transport costs.

For any specific combination of raw material source and market area, a processing plant will be located at that point where overall costs of processing and delivery will be the lowest per unit of product. These various combinations must then be balanced, one against the other, to determine the site which has the lowest relative cost. Generally speaking, we may say that material oriented processing plants will be located at the point of lowest production and transport costs for the principal market area for the product, and will expand sales to those other markets in which it can successfully compete. If an endeavor is to be made to reach many diverse markets, plant location will be conditioned by the lowest average cost of reaching such markets.

Market oriented processing plants will locate at the more important or most advantageous market, but will encroach on such other markets as competition will allow. In some industries there may be a number of processing points of minimum transport costs, dependent upon which material source and which market area is under consideration.

The Soybean Industry

The expansion in soybean production, processing, and

utilization in the United States since 1925 has been one of the most phenomenal developments in American agriculture. Unknown on a commercial scale just 25 years ago, soybeans are now the fourth largest cash grain crop in the United States. This oilseed currently provides over 50 percent of the vegetable oil used in shortening and nearly 45 percent of that used in margarine, as well as about 65 percent of the oilmeal proteins fed to livestock.

Soybean acreage in the United States increased from 1.75 million acres in 1924 to 13.5 million in 1947. At the same time production expanded from five to 200 million bushels. This increase in soybean production was accounted for by the larger acerage; by yields greater by 65 percent than those of 20 years ago; and by an increase in the proportion of acreage harvested as beans from one-third to four-fifths in the past 10 years.

The major soybean producing area in this country has shifted from the southern states to the cornbelt region over the past 25 years. Illinois, Iowa, Indiana and Ohio currently account for 80 percent of total production.

More and more soybeans have been processed commercially as production increased. Over 170 million bushels were processed in 1946-47 compared to one-third of a million bushels in 1924-25, while the percentage of the total crop being processed has increased from six to 83 percent during the same period.

The diversity of uses to which the soybean and its various products may be put covers a wide range. The principal uses, however, are for human and animal food. Nearly 90 percent of the oil processed from soybeans has been used in food products in recent years, with the bulk of it going into shortening, margarine, salad and cooking oils, and salad dressings. Some ten percent of the oil is used in non-food products, such as soap, paints, varnishes, and so forth. The importance of soybean oil in total vegetable oil consumption

has increased markedly; representing 34 percent of total factory consumption of vegetable oils in 1946 as compared to three percent in 1935.

About 95 percent of the soybean meal obtained in processing has been used as a protein feed for livestock. The remainder goes into human food products, industrial products, and fertilizers. Soybean meal has increased in importance compared to the other oil seed meals as a supplier of protein in that this meal represented 64 percent of the total oilseed meals fed in 1946 compared to only one percent in 1926. Although the vegetable oil and protein fields are highly competitive, it appears that soybean oil and meal have found a permanent place in these fields.

Railroad Rate Structure On Soybeans And Soybean Products

Most of the soybeans shipped from country points to processors move by rail, since prior rail haul is necessary for the privilege of transit to be applied. This institution of transit is a "man-made" influence of great importance in the soybean processing industry, since it conditions the normal effects of transportation cost on location. Transit is a procedure whereby a railroad, in respect to particular commodities, grants to individuals or firms at specified locations the right to take possession of goods being transportated from origin to destination for purposes incident to processing, and latter reshipped, with the two seperate movements being considered as one for the purpose of freight rate application. This charging of the through rate from origin to destination, although the shipment is stopped and does not actually move as a through shipment, is a major factor in the transportation economics of the soybean processing industry, and will be referred to in more detail in a later paragraph.

Soybeans generally move on the grain rates, although separate soybean commodity rates are quoted in some instances. Such rates are lower than class rates and vary from

place to place with the degree of competition, the cost of hauling, and pertinent local factors. Through rates are quoted on soybeans between many points, with the lowest combination of local rates applying when no through rate is quoted. This condition often makes rates for equal distances vastly different.

Class rates are quoted on soybean meal when moved by rail, but exceptions to the class rates actually apply in most cases. These exceptions ratings are lower than the class rates, and are applicable on intraterritorial and interterritorial traffic. Commodity rates apply to soybean meal on traffic to Mountain-Pacific Territory. When soybean meal is reshipped under transit, it moves at the through rate from point of origin of the soybeans from which it was processed. Meal moves according to the exception and commodity rates to all territories other than Official. On shipments to Official or Eastern Territory soybean meal takes the grain product rate, which is nearly always the same or slightly higher than the grain rate. This practice is said to exist to "protect" the grain rate to eastern points.

Soybean oil likewise moves at exceptions to the classification rating when shipped by rail, although class rates are quoted. Soybean oil rates are markedly higher than those on soybean meal and on soybeans. Oil rates as between territories vary somewhat from those used intraterritorially, with commodity rates applying to western points.

Soybean oil does not ship from the transit point at the through rate, as does soybean meal under transit, but pays the local rate to destination. This arrangement whereby one product does not reship at the through rate, while others do, is uncommon under transit. Soybean oil is not tied to rail shipment under transit as is the case with meal, although most oil does move by rail.

Transit As Applied To Soybean Processing

The practice of allowing soybean processing under transit

is as old as the bean processing industry. It has been in common usage in connection with grain and grain products for many years and was applied to soybean processing when this industry became of commercial importance in the 1920's.

The practice of extending the transit priviledge by railroads in the United States appears to have originated in order to hold traffic to the lines of a particular railroad in the face of keen competition; to increase traffic on a particular carrier's line; to protect the locational advantages of industries as the country expanded; and to make more efficient use of railroad equipment through better utilization.

The transit privilege as applied to soybeans appears to lack uniformity in its application. It is true that certain general rules of procedure and operation are quite consistent throughout the industry but study of transit tariffs reveals many incosistencies. Limitations on points of origin and destination between which transit will be allowed seem to be discriminatory and conform to no general pattern. The amount of switching and transit charges levied, the extent of back or out-of-line haul tolerated, and the restrictions on routing of both inbound and outbound shipments differ to a marked degree.

Soybean oil is not eligible for reshipment under the through rate as is soybean meal when processed under transit. The through rate is thus applied to approximately 80 percent of the inbound weight of raw material, rather than to move nearly all of the inbound weight as is the case with most grains and grain products. This fact of nontransit on soybean oil ties in with the policy of the Interstate Commerce Commission of denying transit to products whose nature is fundamentally changed in processing, and on which the shipping rate is markedly higher than on the raw material.

Elaborate records and accounts of operations under transit are kept by the processor, in order to preclude the substitution of tonnage and the possibility of reshipping more

tonnage than the inbound tonnage less loss in processing. The duty of policing and supervising these extensive rules and regulations is a responsibility of the railroad and is carried out by Inspection and Weighing Bureaus.

A time limit of 12 months is usually imposed on each transit operation. More than one transit stop may be utilized on the same shipment under certain conditions. Soybean oil is eligible for transit after it leaves the original processing point. The preservation of identity of each individual shipment is not required. Transfer of ownership of soybeans or products at transit point is permissible.

The extent to which transit charges are made on soybean processing varies with the location of the plant, the market to which soybean meal is shipped, and with the railroad extending the privilege. In general, no charge or a very small one is assessed. Extra charges for switching are made in some cases. The through rate applied to a transit shipment is the rate in effect from point of origin to destination on the date of shipment from point of origin.

Routing instructions prescribed by the carrier granting transit are not consistent and vary with the railroad, the territory of origin and the final destination, and depend upon arrangements made with connecting carriers. It appears that such routing instructions are grossly discriminatory as between localities and individuals by limiting or extending the market coverage available to certain producing areas. Some railroads do not extend soybean transit privileges along their lines, nor do they make agreements with connecting lines for transit operations. This jeopardizes producers along such a carrier's line of haul.

Railroads vary in the extent to which they allow back and out-of-line hauls in connection with transit, and the charges that are made for such hauls. The liberality with which such out-of-line hauls are granted often leads to unwarranted wasteful transportation. Decisions by the Interstate Com-

merce Commission relative to soybean transit have been few, with most of them centering around applications for further extension of transit.

Economic Effects Of Transit

Certain general economic relationships appear evident in the institution of transit. The concept that transport rates are a function of distance in the respect that through rates are less than a combination of two or more local rates, does not hold under transit, since in effect the combined local rates are lowered to the level of the through rate. For this reason the importance of transportation as a locational factor is depreciated, since normal freight relationships no longer hold. Plants tending to locate at raw material source under non-transit will continue to do so under transit, although the distance range from raw materials within which they can operate is widened. Plants normally located at the market can likewise operate short of the market under transit.

Intermediate points generally have much greater advantage as processing locations under transit than otherwise, although this is not especially true in the case of soybean processing. Transit tends to influence plant location at a point intermediate to all sources of raw material on the one hand, and intermediate to all market areas on the other. This influence is evidenced in the concentration of soybean processing in Illinois.

Transit has a tendency to reduce the transport costs to a shipper, thus making more favorable his position in regard to total costs. Transit makes it possible to centralize processing in larger and more efficient plants without incurring higher transport cost, and allows access to a greater number of markets. Transit modifies the conventional theory of market areas since it allows processors to compete in the local market as well as in more distant markets along the line of haul, thus equalizing the competitive advantage of various producers.

Transit may result in a more competitive market for the

commodity in question, and adds a certain aspect of fluidity to the market structure. Under certain conditions, processors under transit may favor raw material purchase from more distant sources, because of the favorable transit billing involved.

The application and operation of transit is discriminatory. It is not granted to all commodities, firms, or localities on the same basis. The decision as to what forms of discrimination are to be allowed, and under what conditions, is an important one for the regulatory bodies.

It appears that a high degree of wasteful transportation is often associated with transit. This is difficult to justify from the point of view of the public and of the national transportation policy.

Transit stabilizes the location of plants as raw material and market areas change. This may be good in the short run but should not be condoned over a long period of time.

Transit charges are in general not enough to cover the extra cost of service performed. This is the same as lowering rates generally and appears to be a complicated and expensive means of so doing. The users of transit should pay all of the costs incident to its use.

It appears that if local rates charged for two or more separate shipments are just and reasonable, then the through transit rate less than this combination of local rates can hardly be just and reasonable, since at least as much, and generally more service is performed. This application of the through rate to cover separate shipments tends to break down the rate structure.

The continued use of transit should be measured by the degree to which the public interest is served, mainly in regard to marketing service. There is little doubt that transit does allow for the performance of useful marketing services in the present grain, grain products, and soybean industries. Term-

ination of transit in connection with these commodities would result in chaotic conditions and should be continued in the public interest.

Transport Costs And Soybean Processing Plant Location

The soybean processing industry in the United States is largely a development of recent years. In 1937 there were 26 plants whose major operation was soybean processing, with this number increasing to 47 in 1939. In 1942, 76 plants had a total capacity of 106 million bushels; 71 percent of these being in the four largest soybean producing states of Illinois, Iowa, Indiana, and Ohio. The number had increased to 137 in 1944 and to 160 in 1945. In this latter year 81 percent of the 189 million bushel capacity was in the four states mentioned. In 1948 the 185 soybean processing plants had an estimated capacity of 200 million bushels. From the beginning, soybean processing plants have tended to locate near the source of raw materials for processing. Illinois is the center of both the soybean production and processing industries. It is noted that there is a tendency of the processing plants in Iowa and some of the "fringe" states to be of smaller capacity than those in Illinois. The less the intensity of soybean production, the greater the degree of decentralization in the processing industry. Soybean processing seems to be both a small scale, local business and a large scale centralized operation.

Soybean processing capacity is greater than is needed to handle the current commercial soybean crop, or that expected in the immediate future. Some plants in the soybean belt have already sharply curtailed or ceased production. There are indications that competition among processors for the available supply of soybeans will become increasingly keen. Since the large scale operators have lower per unit costs, it is likely that the smaller plants may be forced out of business unless local sale and freight rate differentials give them sufficient

protection. The adaption of the solvent extraction process to small scale operation may be a boon to the smaller plants.

Rail transport, with its transit privilege, is the central transportation feature of plant location in the soybean industry.

Soybeans are not perishable so this factor does not condition location. Soybean processing is well adapted to large scale, highly mechanized operation. The degree of weight loss in processing of soybeans averages about five percent and is a factor favoring plant location at the raw material area. There is little change in the volume occupied per unit of weight as between soybean meal and soybeans, making this factor of negligible importance in location.

An important transportation influence bearing on processing plant location is the relation of freight rates on raw materials to those on finished products. To points in Official Territory, soybeans and soybean meal generally take the same rate, but on shipments to other classification territories the soybean meal rate was higher (except to west coast points) than the bean rate, as of June 30, 1946. Different territories in the country thus have different relationships, with the southwest generally having the greatest spread between soybean and meal rates. This variation is due to soybean meal moving under transit at the grain product rate to Official Territory, and on the exception to class rates to all other territories than the west coast. To west coast points commodity rates apply that in general favor the raw material area for processing, since soybean rates were higher than meal rates. Rate relationships are not consistent, and favor the market area in one case and raw material area in another. This appears to be nothing more than discrimination among localities.

Soybean oil rates were markedly higher than soybean rates as of June 30, 1946, and since this commodity does not reship at the through rate under transit, this force should tend to

influence processing at the market. Soybean meal rates in general favor the raw material area for processing while oil rates favor the market.

The most concentrated area of soybean production in this country is centered in the 48 central Illinois counties. This area is regarded as the raw material area for our study of Illinois plant locations. For the country as a whole, Illinois, Iowa, Indiana and Ohio represent the supply area of soybeans.

The market for soybean meal is widely distributed within the United States with total demand becoming effective through widely scattered markets. The four soybean producing states mentioned above provide important markets, yet they are surplus producer states of soybean meal. The states most important in soybean meal consumption in 1945 were New York, Illinois, Ohio, Indiana, Pennsylvania, Minnesota, and California; with New York, Pennsylvania, Minnesota, and California being the greatest importers of meal.

Soybean oil is used largely in the manufacture of foods and as such finds its more important outlets near the centers of population. The markets of New York, Chicago, Philadelphia, Norfolk, Memphis, New Orleans, Kansas City, Omaha, Dallas, Denver, and Los Angeles appear to be of most importance. Soybean oil markets are not fixed through a season or over the years because of the interchangeability of various edible fats and oils.

When soybeans originated at 20 country points in Illinois, with the meal and oil being destined to the 20 most important markets respectively, little difference appeared in transport costs as between processing under transit at Decatur, Champaign, and Gibson City, Illinois, although Decatur processors were in a slightly better position to reach all of the 20 oil and 20 meal markets considered. When only the seven most important meal markets and the three most important for oil were considered, processors at these three locations had almost equal transport costs in June, 1946. If the soybeans had been

obtained in the same county in which the plant is located, Champaign, being further east and nearer the most important markets, would have a transport cost advantage. In general though, processors located relatively near each other in the soybean belt have nearly equal transport costs.

It is not advantageous to process soybeans under transit at intermediate points to raw material area and market, because high local rates must be paid on the soybean oil and it is expensive to transport the five percent waste. When such intermediate points, however, are intermediate only for the meal, and are the final markets for the oil, such points appear to have cost advantages. Reshipping costs on oil are eliminated, thus lowering total transport cost. Processing at Philadelphia under these circumstances saves two and one-half cents per hundred over Decatur, while at Dallas eight cents is saved. The important point to assure under these operations is the reliability of the local oil market.

Transportation costs connected with the processing of soybeans at Decatur, Champaign, and Gibson City, Illinois are noticeably lower under transit than non-transit operations, being seven and one-half, eight and one-half, and nine cents lower respectively at the three points. These lower costs appear to involve a direct saving to the processor and the consumer, although it is difficult to see how the carrier gains from such operations.

When transport costs between processing points in each of the four leading soybean producing states to 20 different meal and 20 different oil markets are considered, the Illinois point has a cost advantage. Decatur, Illinois, at an average cost of 41½ cents, is lower than Des Moines, Iowa by two cents; lower than Decatur, Indiana by over three cents; and lower than Painesville, Ohio by five cents. When it is desirable to reach many widely separated oil and meal markets, Illinois processing plants have the advantage because their central location minimizes back-hauls of both soybean meal and oil. When only the more important eastern soybean meal

and oil markets are served, the closer processing locations in Ohio and Indiana have a definite cost advantage. Painesville can reach these markets at the lowest cost, as long as soybeans are available at nearby sources. If soybeans must come from western points, this locational advantage is largely eliminated. Similarly, on shipments to markets in western and southwestern states, the western locations in Iowa are at a cost advantage.

Transit operations provide the lowest freight costs when several markets must be reached. When only one market, or relatively small market area can absorb the oil and meal from an optimum sized plant, thus avoiding any reshipment when processed at such market, soybeans can generally be processed non-transit at such markets at lower freight costs than in the raw material area. Computations for seven important markets indicate that such operations would cost three and one-half cents less per hundred pounds of soybeans than if processed under transit at Decatur, Illinois, as of June 30, 1946. Points in the southwest appear to have greater advantages under non-transit than points in other sections of the country, while west coast points are at a disadvantage. This analysis indicates the influence that differences between rates on raw materials and finished products can have on plant location.

There is apparently a place in the soybean industry for smaller capacity plants serving local areas. Although the costs of operation, other than transportation, of such plants are generally higher than plants of more optimum size, the savings in freight costs resulting from purchase of soybeans and delivery of meal at the plant may be such as to enable such processors to compete successfully for local business. Operation under transit, however, does allow for concentration of raw materials in such quantities as to allow for the most optimum scale of operations.

Transit operations generally favor the raw material area for plant location, as under conventional theory. Thus the

transportation of waste is minimized.

Conclusions

The most important transportation factors affecting soybean processing plant location are: (1) the necessity of locating so as to be able to reach many widespread markets; (2) the existence of the processing-in-transit privilege; (3) the five percent weight lost in processing; (4) the nonapplication of the through rate to soybean oil under transit; and (5) the relationship between rates on soybeans and those on processed products.

In relation to the first of these, conventional theory has never considered this diverse market analysis. Our theory as developed seems to apply to the soybean processing industry, since the number and extent of markets to be served definitely influence location.

Likewise the transit privilege has never been considered in locational theory. In general, transit in soybean processing favors location at the raw material area; encourages large scale plant operations; allows for reaching of diverse markets for joint soybean products from a centrally located plant; and reduces transport costs. On the other hand it is discriminatory; is a force tending to equalize competition and geographic advantage; allows for a great deal of wasteful transportation; and does not appear to be remunerative to the carriers.

The weight lost in processing soybeans favors plant location in the raw material area. The nonapplication of transit to oil favors processing at the oil markets.

The key to soybean plant location is the relationship between raw material and product rates. Large differences between these rates can force location toward the markets when ordinarily the commodity is raw material oriented. Disturbing is the fact that such rate relationships are subject to change.

Other factors than transportation costs are important in the location of soybean processing plants. The most important of these are labor, water, fuel, availability of plant facilities, and capital. Others are personal reasons, chance, ease of buying raw materials, and ease of disposing of finished products. A wise entrepreneur, however, will consider closely the costs of transportation associated with processing at different points before choosing a location for processing soybeans.

VITA

Earl Clifford Hedlund was born at Valparaiso, Nebraska on July 16, 1916. He attended the public schools in Deuel County, Nebraska, graduating from high school in 1933. He received the Bachelor of Science degree from the University of Nebraska in 1938, and the degree of Master of Science in Agricultural Economics from the University of Illinois in 1939.

From September, 1938 to August, 1941 he served as an Assistant in the Department of Agricultural Economics at the University of Illinois, in which capacity he conducted research and extension work in agricultural marketing and taught elementary courses in Agricultural Economics.

In August, 1941 he was called to active duty as a Reserve Officer and served as a Fighter Pilot in the Air Force in both the Pacific and European Theaters of operation. In August, 1947 he resumed his studies at the University of Illinois.

Published writings at the University of Illinois include the mimeographed publications, "Cost Studies on Motor Trucks Hauling Farm Products in Illinois," (1938), and "What Does it Cost to Distribute Food," (1941). He was co-author with R. C. Ashby, R. J. Webb, and Sleeter Bull on Illinois Agricultural Experiment Station Bulletin 479, "Retailer and Consumer Reaction to Graded and Branded Beef," (1941) and was a contributing author on Bulletins 477, "Business Policies of Country Grain Elevators," (1941) L. J. Norton, and "Feeder Cattle Sales at Country Points in Illinois," (1941), R. C. Ashby.

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